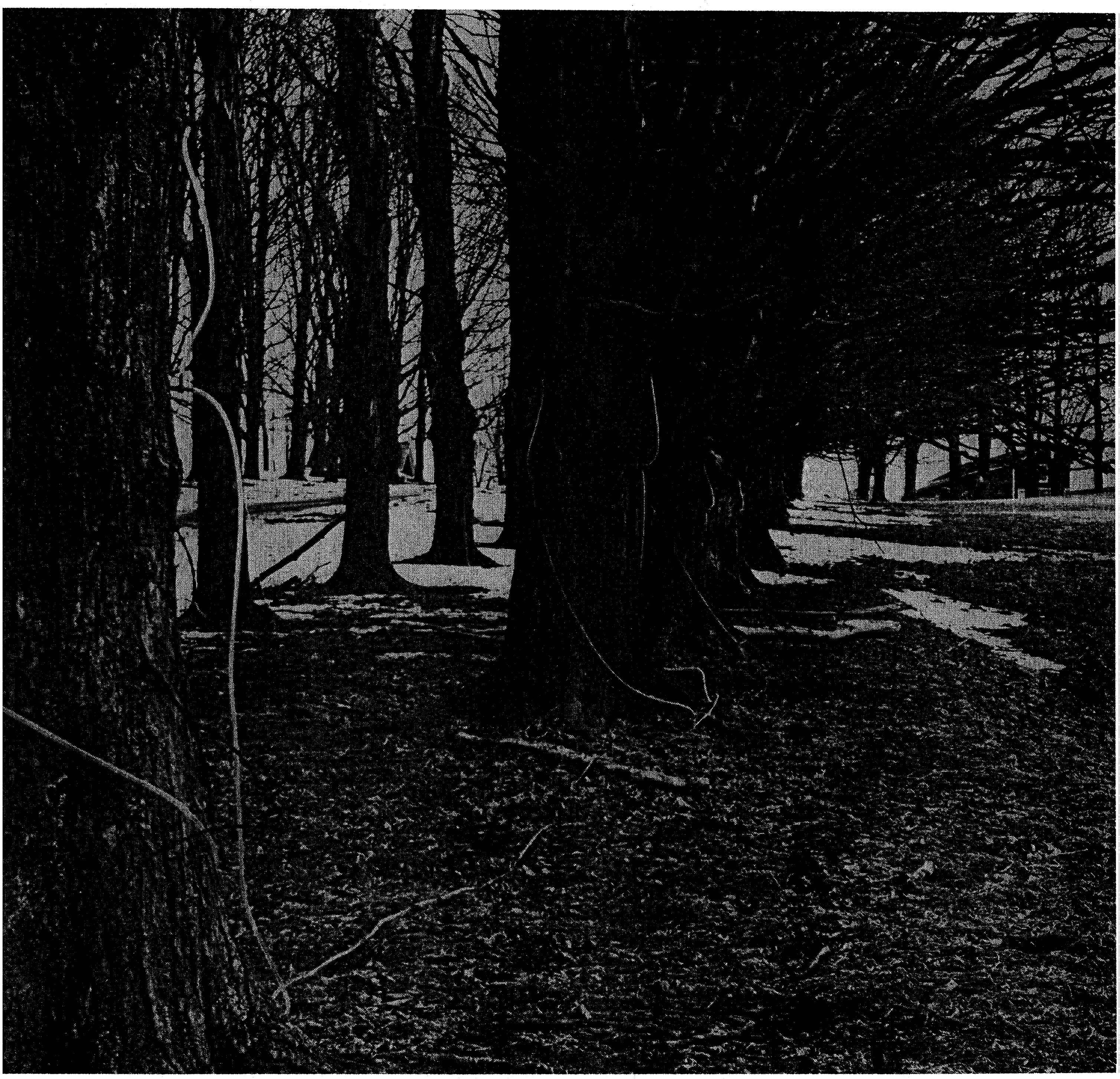
RESEARCH
Modernizes the Maple-Sirup Industry

J. C. Underwood and C. O. Willits

1985



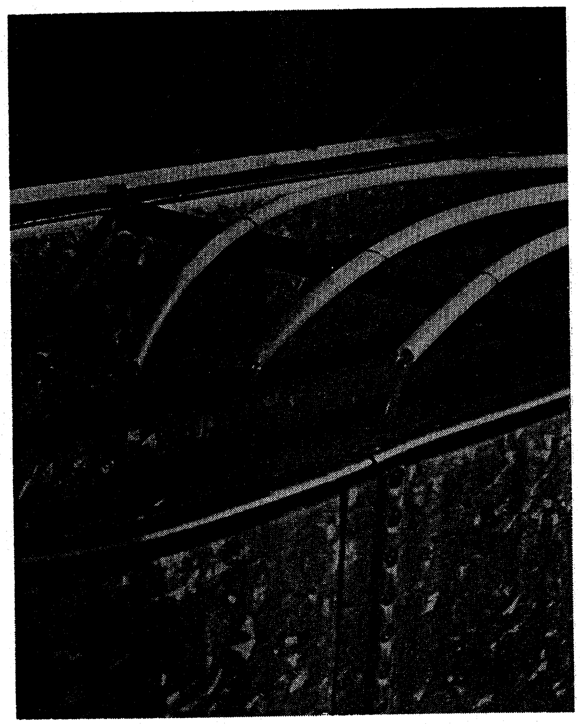
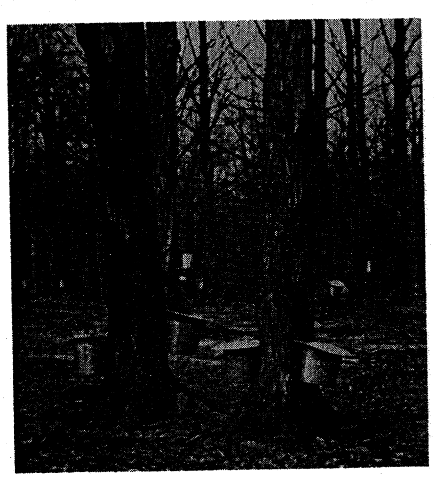


Fig. 1. Sap collection and transport today is accomplished by plastic tubing (see large photo on facing page) which leads the sap from the taphole to the storage tanks (small photo above). This is in contrast with the method shown below in the U.S.D.A. historical photos by M. C. Audsley—the individual metal buckets, and the right-hand scene of the hauling tanks.



■ THE MAKING of maple sirup and sugar was well established when the white man came to America, furnishing items of barter for the Indians living around the Great Lakes and along the St. Lawrence River. Since then, these sweets, which are peculiar to North America, have been produced in hundreds of communities and on many farms from Maine westward into Minnesota, and south to Indiana and West Virginia. However, the industry has remained small even though it is not uncommon for farm incomes from maple-sirup production to reach $200 an acre, paying wages of up to $4.00 an hour. Further, maple-sirup consumption in the United States is approximately twice our production. In spite of these attractive income and market situations, only a small percentage (5–10%) of the available maple trees are being utilized. This situation is due to lack of knowledge about the economic potential of the industry, to the large amount of hard hand labor required, and to the antiquated, unattractive methods of sirup production and processing that are in use. Therefore, a strong research program is being conducted by the U. S. Department of Agriculture and by some of the experiment stations in the maple states to encourage and make possible the expansion of the maple industry and to furnish farmers an inviting diversionary crop that is not in surplus.

The production of uniform, high-quality maple sirup depends on control of the two factors that apply to the manufacture of any acceptable food: a superior raw material and processing techniques that yield an acceptable consumer item.

Fifteen to twenty thousand farmers have been involved in making maple sirup and, consequently, the quality of the product has varied considerably. Successful expansion of the industry depended on the ability of research to develop processing procedures that would enable the maple-sirup producer to make a uniform sirup of high quality. Procedures were required that would: a) be usable by non-technically trained people; b) eliminate current unattractive processing features; c) modernize sirup making; and d) be adaptable to small-scale operations. The last requirement partially disappeared with the recent development of the centralized plant for sap evaporation.

Improved techniques in collecting, transporting, storing, and processing maple sap, primarily the result of this directed research, are reported in this paper.

Collecting, Transporting, and Storing Maple Sap

The popular idea of making maple sirup envisions a small maple producer who gathers sap with horses and sled, in woods heavy with snow, from buckets and rusty cans hung on the trees, and concentrates the sap to sirup in a drafty, steam-filled, damp sugar house with an uneven wood fire. All this has now been changed for farmers who make maple-sirup production a part of their farming operation.

Plastic tubing for gathering sap. By far the most noticeable change in the making of maple sirup since 1900 has been the introduction of plastic tubing for collection and transport of maple sap (Fig. 1). This provides a closed system of sap handling that furnishes a raw material of higher quality. Even more important, plastic tubing has eliminated almost entirely the hard hand labor of sap collection and transport. Mechanical problems had to be solved concerning installation, maintenance, dismantling, cleaning, storage, and reassembly of tubing (Willits *et al.*, 1959; Willits and Sipple, 1961) before it could be used successfully. Development studies are continuing on the type and size of tubing and the kind of installation (open or closed system), but plastic tubing has already contributed significantly to modernization of the industry and is a critical factor in its expansion. The labor needed for collecting sap with buckets not only was costly, since it constituted 40% of the total labor required in sirup making (Bell, 1955), but in many cases was not available. Also, plastic tubing has eliminated the need for construction of roads in the woods and expensive hauling equipment. Further, it has made possible the collection of all of the sap, even from small runs, and has prevented the appreciable losses due to spillage.

Control of sap quality. The maple sap (sweet water), as exuded from the tree, is sterile, and the solids content (about 2%) is essentially sucrose, free of reducing hexoses (Jones and Bradlee; Porter *et al.*, 1954). If this purity and original composition are maintained until the sap is concentrated to sirup (65.5% sugar solids), a light-colored, delicately flavored product results. Edson *et al.* (1912), Hayward and Pederson (1946), and Holgate (1950) established that undue growth of microorganisms in maple sap adversely affects the color and flavor of the sirup. However, Naghski and Willits (1953, 1954, 1957) and Sheneman *et al.* (1959) clarified the deleterious role that microorganisms play in determining the quality of maple sirup. From their work have been developed practical methods of sanitation, applicable to use in the woods and in the sugar house, that are universally used by maple-sirup producers.

Increased yields of sap. In addition to the effect of microorganisms on quality of sap, Naghski and Willits (1953) found that growth of microorganisms in tapholes caused premature stoppage of sap flow. This discovery served as a basis for research at Michigan State University that led to development of a germicidal pellet. This pellet, which inhibits microbial growth in tapholes during the maple season, was made commercially available for the first time in 1962. During the development work and in its first year of commercial use, it has increased sap yields by as much as 100%. Other means of maintaining high quality (low microorganism population and prevention of the breakdown of sucrose) in sap until it is processed have been introduced to producers, i.e., use of clean, sanitized equipment, storage tanks that can be sterilized, and the use of ultraviolet light to retard the growth of microorganisms in sap during storage (Schneider *et al.*, 1960). The latter procedure permits holding sap for longer periods until peak loads in central evaporator plants are passed.

Processing Techniques

Maple sirup is made from sap (sweet water) obtained from the hard maple tree *(Acer saccharum)*. The sap is concentrated by atmospheric evaporation in open pans to a sugar concentration of 65.5% by weight. This is the minimum concentration of sugar in sirup that meets federal and state specifications for a salable product. The characteristic maple flavor and color are developed during evaporation of the sap, which involves exposure to temperatures above 100°C. When the evaporation is done by freeze-drying or under vacuum, only a colorless, flavorless sirup is produced. In other words, flavor and color are not inherent constituents of the sap but are developed by heating. Processing conditions have been established that are optimum for production of the light-colored, top-grade, highest-priced sirups with distinctive full maple flavor (Finlay and Snell, 1910); Porter *et al.*, 1952).

The discovery that sap becomes sufficiently alkaline, soon after it begins to boil in the evaporator, to cause the break-down of any reducing hexose sugar indicated the possible mechanism of color development. Since dark-colored sirup is recognized to contain more invert sugar than the lighter grades (Edson, 1912), the color could come from the degradation of these reducing sugars, which are in sap as a result of microbial growth or chemical reactions. Carbonyls related to alkaline hexose break-down products have been isolated from maple sirup by steam distillation (Underwood, 1957). Further, the development of maple color is influenced by the time required to produce sirup by atmospheric boiling. This time is governed by two factors: a) the amount of heat applied to the evaporator, and b) the volume of sap in the evaporator (hold-up time). The ideal is to increase *a* to a maximum and to reduce *b* to a minimum (Porter *et al.*, 1952; Willits *et al.*, 1952).

The time effect becomes progressively critical as: a) the concentration approaches that of standard sirup, especially above sugar concentrations of 40° Brix and b) the concentration of invert sugar increases.

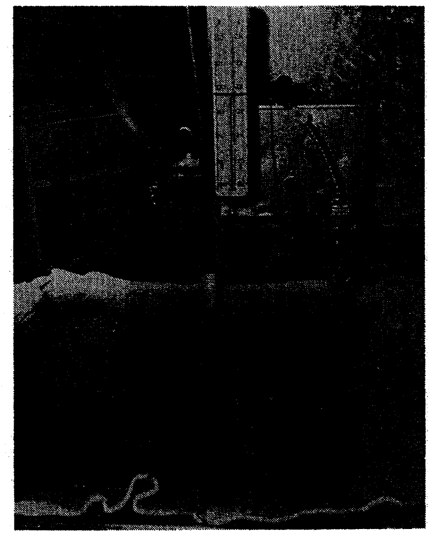


Fig. 2. Modern equipment controls the production of maple sirup today: special thermometer, automatic draw-off valve, and synthetic felt filters.

From these observations, processes have been evolved that control these factors to obtain sirup of the desired color.

The open-pan atmospheric evaporator is well suited to the usual small-size operation found in the individual and central evaporator plants, and is adequately efficient (Strolle 1956) to be continued as the basic equipment used in concentration of sap. However, it is now being complemented with accessories to obtain better control of the processing factors. These include the substitution of oil, or high-pressure steam, for wood as the heat source, to obtain a steady maximum rate of evaporation, and separate pans, in which the final stage of evaporation is done batch-wise. Instruments have been developed or adapted for precise control of the end point of evaporation. Standard-density sirup (65.5°Brix) boils at 7°F above the boiling point of water at any barometric pressure. Special thermometers have been designed for maple-sap evaporators (Fig. 2) that relate sirup temperatures to boiling-water temperatures. Automatic valves have been developed to withdraw sap and/or sirup from the evaporator at any desired sugar concentration.

The open-pan evaporator has now been provided with a tight-fitting cover (Fig. 3) with a stack for the removal of steam from the evaporator house. This new venting system not only keeps dirt and other foreign material from falling into the boiling sap but also produces a warm, steam-free evaporator house. Sanitary practices can now be followed in such houses as in other food processing plants.

Central evaporator plants. The technological improvements in the collection, transport, storage, and processing of maple sap has initiated another recent advance that is having a great impact on the maple industry: establishment of the central plant for evaporation of sap to sirup. Prior to this, all sirup was processed on the farm that produced the sap. Now, for the first time in the history of maple-sirup making, it has become possible to separate sap production from sap processing. These plants serve entire communities and create a market for sap alone. They are bringing into use many sugar trees now idle because of labor shortages or, more particularly, because of a lack of equipment and capital needed for construction of individual evaporator houses. Only a limited capital investment and a minimum of labor are required to put a "sugar bush" into operation to supply the central plant. The major obstacles have been removed for the utilization of vast stands of unused trees. Already the maple industry is expanding markedly. Many of the new sugar bushes are on marginal lands in our rural areas and are providing much-needed cash incomes for their owners. Sap production for the central plants is proving to be as profitable to the farmer as when he carried out his own sirup-making operation. (Fig. 4).

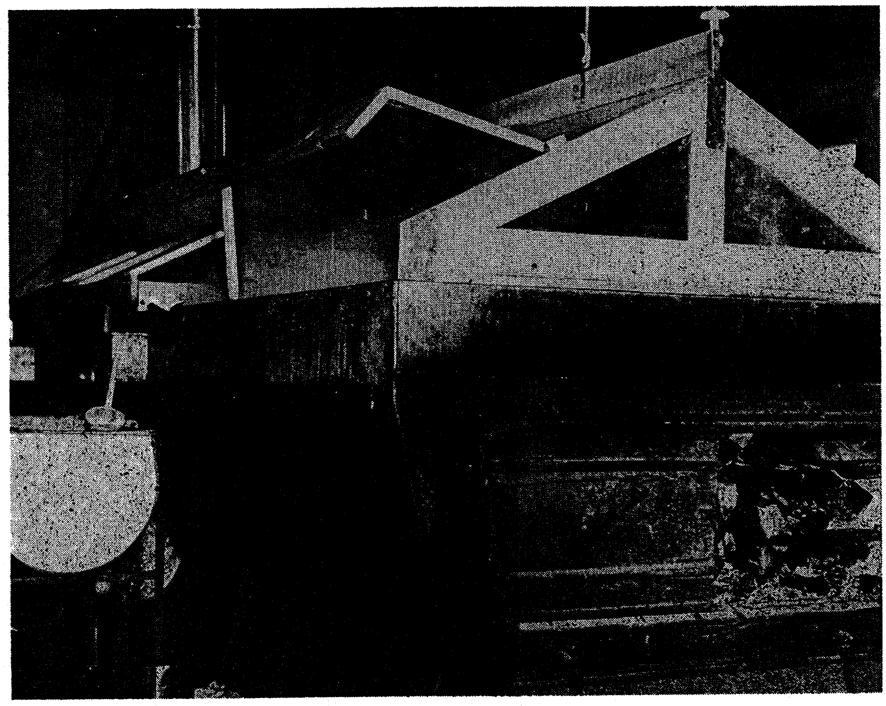
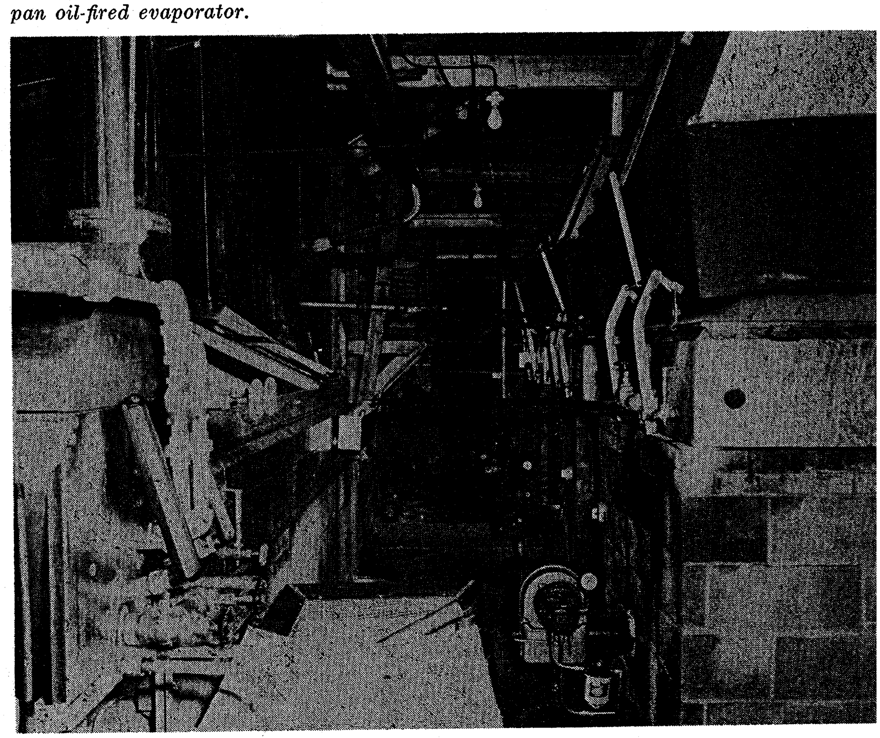


Fig. 3. The closed steam-venting system on evaporators makes possible sirup making in a clean, steam-free room, as demonstrated by the covered evaporator with steam stack.

Fig. 4. An interior view of a typical modern maple-sirup plant, showing a multiple-pan oil-fired evaporator.



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